White light fringe modeling for the SIM CCD detector.

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This paper addresses the issue of the white light fringe modeling as needed for the phase information extraction with the Space Interferometry Mission (SIM) CCD detector. We developed a set of analytic expressions for the white light fringe estimation using the complex visibility phasors. The obtained expressions are valid for an arbitrary number of detector spectral channels and for an arbitrary number and sizes of the PZT dither steps. In particular, the expressions may be used to obtain estimators of the real, X_ℓ, and imaginary, Y_ℓ, phasors, as well as for the total intensity of light in the ℓ-th spectral channel $\mathcal{P}_{0\ell}$ that are given as:

$$X_\ell \equiv \mathcal{P}_{0\ell} V_{0\ell} \cos\phi_\ell = \frac{1}{\mathcal{D}_\ell} \sum_{j=1}^{N} K_{\ell j}\, \mathcal{A}_{\ell j},$$

$$Y_\ell \equiv \mathcal{P}_{0\ell} V_{0\ell} \sin\phi_\ell = \frac{1}{\mathcal{D}_\ell} \sum_{j=1}^{N} K_{\ell j}\, \mathcal{B}_{\ell j},$$

$$\mathcal{P}_{0\ell} = \frac{1}{\mathcal{D}_\ell} \sum_{j=1}^{N} K_{\ell j}\, \mathcal{C}_{\ell j},$$

where $K_{\ell j}$ being the flux registered by CCD detector at ℓ-th channel at the j-th PZT dither step. Coefficients $\mathcal{A}_{\ell j}, \mathcal{B}_{\ell j}, \mathcal{C}_{\ell j}$ and $\mathcal{D}_\ell$ that depend only on the sizes of individual PZT steps, the width of a particular spectral channel Δk_ℓ with the mean wavenumber k_ℓ and corresponding wavelength λ_ℓ, and on the photon statistics for a particular temporal bin. Index j is a summation index that defines a particular temporal bin; index ℓ is used to define a particular spectral channel. We discuss implementation of this formalism for the SIM detector in light of our simulations of the residual group delay estimation and suggest directions for further research on this problem.

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